MANAGEMENT OF REDUCED CO2 EMISSION PRODUCTION IN MEAL DELIVERY USING POINT TO POINT SYSTEM

Kovač V., Vochozka M., Fulajtárová M., Janíková J.*

Abstract: The goal of the paper was to propose a system of ready meal delivery in the Point To Point mode (PTP) that would lead to a reduction in delivery times and production of CO2 emissions compared to the standard in the Czech Republic. This study proposes a fresh approach with the potential to revolutionize the regional meal delivery sector by strategically integrating distribution centers and addressing economic factors. The appropriate location for distribution centers created for meal delivery to the final consumers can be determined using many methods. As the most suitable one, the center of gravity location method depending on the distance and number of orders and deliveries to given localities was selected. The calculation of the Return on Equity was used to determine the return on investment necessary for the implementation of the proposed solution. The research shows that the implementation of the proposed solution would reduce the production of CO2 by more than 12 %, along with the reduction of fuel and operating costs of vehicles used for delivery services. At the same time, it would be possible to shorten the delivery times by 40 %. The findings show that the average delivery time, which ranges from 66 to 116 minutes, has a substantial influence on competitiveness, resulting in customer attrition. The research also detects varied amounts of CO2 emissions, with the principal vehicle emitting 37.4 kg of CO2 each day. The suggested strategy emphasizes delivering meals to strategically located distribution centers while maintaining temperature and hygiene compliance. This strategy has the potential to minimize vehicle kilometers traveled and CO2 emissions, thereby improving operational efficiency. Finally, the research shows the potential for an innovative method to revolutionize food delivery services, benefiting both businesses and the environment.

Keywords: Point to Point, distribution centers, warehousing, logistics, delivery services, meal delivery

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Introduction

An extensive competitive environment in the field of transportation and warehousing enhances constant innovations and development of logistics. The implementation of organizational forms such as integration and flattening, fast development of technologies, and the introduction of management concepts such as industrial linkage and supply chains leads to the need for the constant development of logistics and the use of systems with functions like visualization and automation, which turn out to be an inevitable trend and the main goal of modern logistics development (Ouyang et al. 2019; Olah et al. 2021; Bumba et al. 2023). Intelligent logistics is an efficient way to face the challenges of rapidly changing customer requirements, use opportunities brought by new technologies, and facilitate the application of new business models (Yangke et al., 2021; Skare et al. 2023; Deja et al. 2021). The method and level of logistics are determined depending on the environment; the European freight transport market is mainly dependent on road transport (Durana et al., 2019). Road motor vehicles constitute an important part of inland transport. In 2016, road transport accounted for 75 % of the total tonnage of goods transported in Europe (Kedzior-Laskowska 2020). The worst stage of the whole transportation chain is referred to as the last mile. As the last leg between the customer and supplier, it is considered to be the most expensive and complex part. The last mile is the most financially demanding and time-consuming for suppliers, featuring noticeable negative effects in the form of pollution and traffic congestion in densely populated areas. With the advent of e-commerce, the number of individual home deliveries increased, which increased last-mile flows (Cardenas et al., 2017; Gavurova et al. 2018). Within goods delivery, the last mile is being paid increasingly more attention to by experts from practice, researchers, as well as public administration bodies. This issue can be encountered even in the case of food and meal delivery where Point To Point is one of the most suitable options to solve the last-mile problems related to delivery (Cardenas et al., 2019). If the number of PTP shipments is sufficiently high, it is beneficial both for the supplier and the customer due to the lower number of vehicle kilometers traveled and the time saved during transportation (Cardenas et al., 2017). Customers require reliability and short delivery times, which has become one of the most important elements considered in designing transportation systems and transportation itself. According to various international studies, guaranteeing reliable delivery times represents a strategic competitive advantage (Gaston Cedillo-Campos et al. 2019; Gavurova et al. 2022; Petkovski et al. 2022). Currently, new distribution channels are being sought, which applies also to food delivery. This would enable meal delivery under suitable storage conditions (temperature) at a suitable time (Keeble et al., 2020). During the global COVID-19 pandemic in 2020, the number of online orders for food delivery increased as it provided consumers with easier access to meals and allowed food delivery providers to continue operating these services (Li, Mirosa and Bremer 2020; Suzuki, et al. 2023). This has given rise to several new applications that facilitate food delivery, such as emerging online-to-online mobile technologies, which have been widely adopted by food businesses and customers, mainly because they provide win-to-win food delivery services that help companies to be in touch with their customers even outside the restaurants (Zhao and Bacao 2020). From an economic perspective, online food delivery provides job and sale opportunities; however, it is criticized for the high commission these companies charge restaurants and the questionable working conditions of its employees. Another negative factor is the impact of these companies on the environment in the form of significant generation of waste and a high carbon footprint (Mirosa, and Bremer 2020). In the future, all stakeholders need to consider how to mitigate these negative effects and enhance the positive effects food delivery has to ensure its sustainability in every aspect. PTP food delivery reduces the number of kilometers traveled by couriers and thus the volume of generated CO2. Just to provide a clear picture, in 2019, the major online food delivery companies Just Eat (including subsidiaries) and Uber Eats were available in 45 countries, Deliveroo in 12 countries, and Grubhub was established in most major US cities; the availability of online food delivery services is expected to increase, which could lead to their greater use (Hwang and Kim 2019). Therefore, mobile applications have seized this opportunity and adapted it to restaurants and food delivery services, which are considered to be an alternative strategy for increasing sales revenue and convenient acceptance of products and services by consumers (Cho et al., 2019). It has been found that customers use food delivery mainly for convenience, based on restaurant experience, delivery experience, quality, and easy use (Ray et al., 2019).

The goal of the paper is to propose a system for meal delivery in the Point To Point mode that would lead to reducing delivery times and the production of CO2 emissions compared to the current standard in the CR.

By answering research questions, it will be possible to find out information about the distribution of meals in the CR, the current delivery times, and the production of CO2 emissions in the distribution of meals.

RQ1: What is the current standard in delivery times and CO2 emissions within meal delivery in the Point To Point mode in the CR?

Furthermore, it is necessary to deal with the individual aspects of delivery, with a special focus on the “last mile” issue, which is the most time-consuming for courier services and is associated with the largest production of CO2, especially to increase competitiveness and sustainability.

RQ2: Which parameters of meal delivery can be changed to make it faster and with a lower generation of CO2 emissions?

Based on the findings obtained, we will propose alternative delivery using the Point-to-Point system, which is expected to help the easier connection of customers and suppliers. Subsequently, the proposed system will be compared with the current standard in the CR.

RQ3: Is it possible to propose a model of meal delivery within the Point To Point mode, which would lead to the reduction of delivery times and production of CO2 emissions compared to the current standard in the CR?

Literature Review

There are various tools to monitor customer satisfaction. Safaeian et al. (2019) state that an appropriate supplier monitors customer satisfaction, which enables improvement in the final product as well as the competitiveness of a given company. The customer satisfaction rating system is also addressed by (Liang et al., 2021) based on an analysis of online reviews. As a logical index, the authors use the European Customer Satisfaction Index and the method of measuring the quality of services that considers the performance of services (Dvorakova et al., 2021). For measuring customer satisfaction, an assessment method was proposed consisting of the partial least squares structural equation modeling, as it systematically analyses satisfaction with public transport services (Zhang et al., 2019; Kuzmenko et al. 2023). For this purpose, it is also possible to use a fuzzy comprehensive evaluation method and thus create a mathematical model for evaluating customer satisfaction (Zhou and He 2019). An important topic of research in the field of service quality evaluation is how to effectively set up resources to achieve maximum customer satisfaction. Safaeian et al., (2019) propose a method of service quality evaluation in a fuzzy environment where customer satisfaction is the main goal while also considering the limitation of corporate resources and fuzzy information about customer evaluation. The basis of fuzzy logic is the approach of considering fuzzy sets, which, unlike Boolean sets, work with real values from the interval [0;1] (Mockor and Hynar 2021). For the customer satisfaction evaluation index, Chen et al., (2019) used the method of a questionnaire survey, which enables obtaining primary data that have not yet undergone any transformation. This means this is elementary information subsequently processed according to a sector under review. However, in the processing of primary data, there is often a problem with the skewed perspective of data distribution of one class over the other (Kaur et al., 2019). A questionnaire survey is a suitable tool for obtaining primary data (Kasych et al., 2020). To obtain primary data Zameer et al., (2020) also used a questionnaire survey distributed to customers of a given company and were thus able to assess the services and products offered. The quality of the data obtained through the questionnaire depends on the number of respondents. For example Huang (2021) worked with 173 completed questionnaires, while Yoda and Katsuyama (2021) used more than 1100 completed questionnaires, arguing that the more respondents fill out the questionnaire, the more precise and reliable data are obtained. In practice, there are more types of questionnaire surveys, with the most commonly used one being an online questionnaire survey due to its easy sharing, lower costs, and overall comprehensibility. For these reasons, Singh et al., (2020) also chose this type of questionnaire. There are other types; for example, Sturgeon et al., (2018) use telephone interviews for collecting primary data. This method is more expensive and time-consuming but enables a better connection between the respondents and the creators of the questionnaire. Becker et al., (2020) collected primary data using a postal questionnaire.

Another method for primary data collection is used by Insausti et al., (2020), who applied the observation method for each activity to obtain important data necessary for the implementation of appropriate control measures. Qualitative observation is used for collecting data from a large number of respondents where individual activities are monitored (Wu et al., 2020). However, Gutierrez et al., (2019) argue that the common observation methods can be inefficient and that computer systems and recent advances concerning deep learning can play an important role in increasing efficiency. Lv et al., (2018) thus proposed the method of continuous observation based on artificial neural networks that make a quantitative analysis of individual events. The same conclusion was made by Bai et al., (2018), who compared the efficiency of the conventional manual observation method and the method of automatic observation proposed by them. Based on this comparison, they conclude that the automatic observation method is more efficient.

Siekelova et al., (2019) use several indicators to evaluate the return on investment in practice where profitability ratios are important economic indicators affecting the viability and sustainability of services, which are factors considered in most corporate policies (Samartzis and Talias 2020). For each level of technological readiness, suitable profitability ratios are applied. Static indicators are preferred for earlier levels of technological readiness, while dynamic calculations are preferred for later detailed forecasts (Buchner et al., 2018). In practice, most authors use the analysis of the development of the main profitability ratios, specifically Return on Assets (ROA), Return on Equity (ROE), Return on Investments (ROI), and Return on Sales (ROS) (Ercegovac et al., 2020), (De Blasio et al., 2022).

Obtained data are usually analyzed using content analysis Dehnavieh et al., (2019), which is increasingly more often used in literary reviews to assess prior knowledge and understand the content structures. However, it is often misunderstood and incorrectly applied (Gaur and Kumar 2018). Lindgren et al., (2020) state that qualitative content analysis and other "standardized" methods are sometimes considered to be technical tools used for basic, superficial, and simple text sorting and the results may lack sufficient information value (Sedliacikova et al., 2021).

The optimal location for the distribution center is of strategic importance for most companies supporting and increasing competitiveness thanks to shorter delivery times, which ensures greater customer satisfaction. Brasileiro and Chiuffa (2018) use the simulation of three different scenarios with unique characteristics for determining a suitable location for the distribution center (Hasanzadeh and Seifbarghy 2018). To solve this problem, the authors use a genetic algorithm and variable neighborhood search. The numerical results indicate that a higher-quality solution is generated by a genetic algorithm. (Habibi et al., 2023) use a mathematical model for determining the location of distribution centers to minimize the overall costs of inventory and distribution. The proposed model falls into the category of

NP-hard problems. For this problem, the authors developed a metaheuristic algorithm. Such mathematical models can be used with the help of a modified genetic algorithm (Ghasemi and Khalili-Damghani 2021). Many quantitative and qualitative criteria need to be considered when selecting a suitable location for distribution centers. Therefore, distribution center selection can be viewed as a multi-criteria decision-making (MCDM) problem in an undefined environment single-value complex neutrosophic sets (SVCNS), which are a generalization of fuzzy sets. Quynh et al., (2020) propose a new approach, a Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) based on SVCNSs to determine the location of distribution centers. In the proposed TOPSIS approach, SVCNS are used to assess and evaluate weights of criteria importance, evaluation of alternatives, and their aggregate values. Yu and Khan (2022) deal with the reduction of carbon emissions. For determining a suitable location for distribution centers, the authors integrated the theory of stochastic programming and fuzzy mathematical programming and subsequently used the Monte Carlo simulation.

Another possible solution to the issue is the problem of the p-median to solve location facilities problems (Montoya et al., 2020). The hard p-median problem can be formulated as a constrained binary linear program Lin and Guan (2018), which is based on the center of gravity location method. The center of gravity method is a non-derivative alternative to the p-median problem that can provide similar results (Panteli et al., 2021). Liu (2019) uses the center of gravity method for a balanced location of distribution centers within the logistic chain; in contrast, Causado-Rodriguez et al., (2018) argue that this method is purely quantitative and considers only aspects such as demand and location coordinates of the production site and its use is thus insufficient. This issue is addressed also by J. Li (2019). To prevent the limitations of the traditional algorithm for selecting the center of gravity, the value of geographical location was included in the optimization algorithm as the weight value and the total costs of the model were calculated. Next, a three-segment clustering algorithm was introduced in data mining to improve the clustering calculation efficiency and prevent isolation.

For primary data collection, this paper uses the conventional method of quantitative observation whose results are analyzed using quantitative content analysis to be able to answer research questions 1 and 2.

To answer research question 3, the value of the return on investment will be calculated using the return on equity necessary for building new distribution centers. An appropriate location for distribution centers will be calculated using the center of gravity location method.

Research Hypotheses and Methodology

As in the Czech Republic, no meal delivery company uses the Point To Point system, the current time standard and generation of CO2 cannot be adequately described. For this reason, the conventional method of meal delivery used by most delivery companies will be monitored. To answer the first and second research questions, a

company providing meal delivery service will be observed using the method of quantitative observation in the period from 1 January 2020 to 30 December 2020 and the delivery times from ordering the meals to their delivery to the final customer will be monitored. Based on the obtained data, the average delivery times are calculated using quantitative content analysis. For determining the production of carbon dioxide, a similar method will be used where the kilometers traveled and the average fuel consumption of individual vehicles used for food delivery will be monitored every day. Using the average daily kilometers traveled and the fuel consumption of these vehicles will be calculated using content analysis. To be able to answer the first and the third research question and compare the current situation with the Point To Point system proposed in this paper, it is necessary to calculate the production of CO2 generated during the delivery. The generation of carbon dioxide is specified in the technical parameters of the vehicles; however, for greater accuracy, it is more suitable to calculate the production individually for each vehicle.
The calculation of CO2 production in the case of gasoline engines is based on the following information: the weight of 1 liter of gasoline is 750 g, of which 87 % is for carbon, which corresponds to 652 g of carbon in one liter of gasoline. To burn 1 liter of gasoline, 1740 g of oxygen is necessary. The generated volume of carbon dioxide thus equals the sum of 652 g of carbon and 1740 g of oxygen. In total, 2392 g of CO2 is produced from one liter of gasoline burned.
The same method is used for calculating CO2 production in the case of LPG and CNG-powered vehicles, with LPG engines producing 1665 g of CO2 from one burned liter of liquefied petroleum gas and CNG engines producing 2666 g of CO2 from one burned kilogram of compressed natural gas.

The total production of CO2 per kilometer can be calculated as follows (Neugebauer et al., 2022):

$$E_{pp} = e_p * \frac{S_b}{100} \tag{1}$$

Where Epp represents total CO2 emissions per 1 km [g CO2], ep – CO2 emissions produced by burning 1 liter of gasoline [g-CO2/L], Sb – average gasoline consumption of vehicle [L/100 km], The annual consumption for individual vehicles will be calculated as follows (Neugebauer et al. 2022):

$$E_{pp} = e_p * \frac{L * S_b}{100} \tag{2}$$

Where Epp represents total CO2 emissions per 1 km [g CO2], ep – CO2 emissions produced by burning 1 liter of gasoline [g-CO2/L], Sb – average fuel consumption of a given vehicle [L/100 km], L – number of kilometers traveled within the reviewed period of vehicle operation. [km].

To be able to answer the third research question, several methods need to be used. First, it is necessary to determine a suitable location for distribution centers based on information obtained from answering the previous research questions. The location will be calculated using the center of gravity location method, which is based on the volume of goods and the distance between individual points. The position is indicated using the Cartesian coordinate system using the letters X and Y, which enable distinguishing individual positions from (dxa, dya to dxi, dyi). Next, it is necessary to express the workload of Vi, which represents the number of meals delivered to specific addresses within the monitored period. The coordinates of individual destinations are then multiplied by relevant transport performance in the denominator, and each transport performance is added to the denominator where all transport performances are added up and the resulting load is determined. This way, the system prefers and brings the resulting facility to the points with more frequent shipments. The resulting coordinates will be Cx and Cy.
The basic equation for calculating the coordinates is as follows (Chase et al., 2006):

$$C_x = \frac{\sum d_{ix} * V_i}{\sum V_i} \tag{3}$$

$$C_y = \frac{\sum d_{iy} * V_i}{\sum V_i} \tag{4}$$

Another method used for answering the third research question is the calculation of return on equity (ROE), which helps outline the return on investment necessary for building new distribution centers to achieve a better flow of meals. Return on equity invested in the newly proposed solution can be expressed as a ratio of net profit and equity.
The basic equation for calculating ROE (Gomes and Oliveira, 2021) is as follows:

$$\text{ROE} = \frac{income}{equity} \tag{5}$$

Finally, to answer the third research question, the method of comparison will be used where the results provided by the newly proposed solution and the current standard in meal delivery in the Czech Republic will be compared.

Research Results

During the monitored period from 1 January 2020 to 30 December 2020, the company Pizzaservis Český Krumlov operating in the delivery of meals in Český Krumlov and its surroundings was monitored. For delivery, the company uses three cars and one vehicle.
For the calculation of the current production, the information in Table 1 was used.

Table 1. Vehicles used in the company

VEHICLE USED FOR DELIVERY	TYPE OF FUEL	AVERAGE FUEL CONSUMPTION	ANNUAL MILEAGE [KM]
Škoda CITIGO	CNG	5.4 [KG/KM]	96656
Fiat PANDA	LPG	5.1 [L/KM]	55455
Fiat 500x	GASOLINE	11.5 [L/KM]	2562
Honda PCX	GASOLINE	3.9 [L/KM]	3489

Based on the values listed in the table, it is possible to calculate the annual production of CO_2 generated within food delivery. In total, 19,645 kg of CO_2 is generated by the activities related to food delivery and supply per year.

When monitoring the standard of food delivery in the company Pizzaservis, it was found that delivery times differ depending on many factors. The average delivery time in the monitored period was 93 min 45 sec. The factor that most affected the length of the delivery time is the company's workload, which is different at different times of the day. The longest delivery times were recorded in the evening hours when there was the highest number of orders and during the rush hour due to the couriers´ delays in delivery on the last mile. In the final stage of delivery, the courier must contact the customer and deliver the order to the final consumer. At this point, several activities negatively affected the length of the delivery times. The delays mostly occur when couriers deliver the orders to blocks of flats and deliver the orders to customers´ doors. This activity took on average 3-10 minutes. At the same time, there were situations when couriers could not contact customers although they were already waiting at the point of delivery.

The proposed solution is based on the deployment of distribution centers in the places with the highest concentration of orders within the given area. These conditions are usually met by places such as housing estates and city districts with a higher number of apartment blocks close to each other. Couriers will deliver the ordered meals into the Pizza boxes based on orders in the application where customers can choose a meal, pay for it, and then select the method of delivery.

In the monitored period, individual orders were monitored including the delivery address, the content of orders, the time of orders, and the total time from entering the order until its delivery to the final consumer. To determine a suitable location for distribution centers, Český Krumlov will be divided into individual geographical zones and they will be assigned individual data on orders (see Table 2).

Table 2. Orders assigned to individual zones

Zone	ANNUAL NUMBER OF DELIVERED MEALS [pcs]	ANNUAL NUMBER OF ORDERS	AVERAGY DAILY NUMBER OF DELIVERED MEALS [pcs]	AVERAGE DAILY NUMBER OF ORDERS	AREA [KM ^2]
Plešivec housing estate	11700	6318	32.05	17.31	0.255
Plešivěc suburbs	774	486	2.12	1.33	0.089
Inner town	2934	1620	8.04	4.44	0.1789
Nové Spolí	2448	1188	6.71	3.25	0.342
Horní Brána	10746	5634	29.44	15.44	0.3654
Špičák	4680	2520	12.82	6.9	0.3721
Dobrkovice	1026	648	2.81	1.78	0.3148
Mír housing estate	9501	5220	26.03	14.3	0.152
Tovární	1998	1008	5.47	2.76	0.484
Vyšný and neighbourhood	8064	3924	22.09	10.75	0.478
Za Nádražím housing estate	7758	3878	21.25	10.6	0.221

Using the quantitative analysis based on observation, it was found that in 2021, the pizzeria executed a total of 33,482 orders, in which 64,387 meals were delivered. As for the number of orders per area, the most deliveries were made to the following zones: housing estate Plešivec – 24,7776 orders per 1 km^2, housing estate Mír – 34,342 orders per 1 km^2, and housing estate Za Nádražím – 17,547 orders per 1 km^2. Therefore, the most advantageous location for the distribution centers is approximately in the center of these three zones, with the possibility of connecting to the public electricity grid.

Using the center of gravity location method, the appropriate location for distribution centers was calculated for each zone based on the Cartesian coordinate system of each address and the volume of orders delivered to the given address. For simplification of the calculation, the zones were divided into streets and sections of streets and the following results were obtained: for the Plešivec housing estate, the most suitable location for the distribution center is Plešivec, No. 367, which is an ideal location for the customers and enables connecting to the public electricity grid which will supply the distribution centers. Similarly, the housing estate Mír consists mainly of blocks of flats, and the zone was divided into individual streets according to house numbering. Here, the most suitable location for the distribution center is the block of flats with the address 153 Urbinská, where it is also possible to connect to the public electricity grid. Housing estate Za Nádražím consists of both houses and blocks of flats. The most suitable location for the distribution center appears to be the basic school (Za Nádražím), which is situated in an ideal position for the higher concentration of orders delivered to the blocks of flats. Also, this provides the easiest connection to the public electricity grid. Within these three zones, the maximum distance to the nearest distribution center is 482 m.

The savings on fuel and the associated production of CO_2 emissions are not significantly high, since the distribution centers are located approximately in the middle of the zones. It would make a difference if the courier delivered 2 or more orders to one distribution center. The number of orders delivered to the same distribution center was calculated from the values obtained in the first part of the research based on the number of orders delivered to a given zone at a given time. Based on the calculation, it can be concluded that in 12.3 % of situations 2 or more orders will be delivered to the same point. This means that vehicles will travel 12.3 fewer kilometers, which means a reduction of CO_2 emissions by 2 416 kg, savings on fuel, and vehicle operation of 43 000 CZK per year.

The costs of building the distribution centers are divided into one-off and periodic costs. One-off costs are represented by costs of acquisition and development of distribution centers, their installation, employee training, purchase of necessary hardware, the development of software for ordering meals, costs of promotion and advertising, as well as the costs of testing the solution proposed. The total calculated one-off costs were 835,000 CZK. Periodic costs include rental costs, costs of cleaning supplies, operating costs, costs of the distribution center service, costs of SW operation and maintenance, advertising costs, costs of revision of distribution centers, SW updates, and regular employee training. These costs were calculated at 161 768 CZK per year. Operating costs shall include the operation of both chambers of the oven in which the meals are prepared to ensure a sufficiently fast production of meals, which amounts to 38 263 CZK per year. The total costs of the first year of operation of the distribution centers will be 1 035 031 CZK.

Due to the faster delivery, the implementation of the new solution is expected to attract customers who currently do not use these services and encourage the existing customers to use these services even more. If the production increases by the expected 5% the profitability of the new solution will be 0.602 in the first year of its use and 1.0412 in the second year. After the third year, a significant return on investment of 537 935 CZK (ROE = 1.382) is expected.

Discussion

RQ1: What is the current standard in delivery times and CO2 emissions within meal delivery in the Point To Point mode in the CR?

As already mentioned, the Point To Point system is not currently used in the Czech Republic. This system is widely used mainly for the transportation of smaller shipments. The most widely used platforms for the distribution of meals include applications such as Dáme jídlo, Bolt food, Wolt, Uber Eats, and others that mediate meal delivery for restaurants that do not operate their delivery services. However, the majority of companies provide delivery services, which are more costly depending on the operation of their vehicles, employees, advertisement, etc.; on the other hand, no share is paid to intermediaries. Operating its delivery service pays off for companies that are primarily focused on meal delivery rather than on running a restaurant (McCain et al., 2022).

The average delivery time depends on several factors, such as workload, the position of the restaurant, traffic, the distance between the customer and the restaurant, etc. In the company under review, the delivery time ranged between 66 and 116 min. Such values can be classified as rather long delivery times, which results in lower competitiveness. Due to long delivery times, the company loses customers who do not want to wait long for their meals.

The production of CO_2 emissions differs depending on the vehicles used for delivery. The company under review uses two vehicles every day, with the primary one being used throughout the day, traveling approximately 282 km and producing about 37.4 kg/CO_2 every day. Similar values are recorded for most vehicles intended for meal delivery in the Czech Republic; similar results were also achieved by Tsuji et al., (2020) in their study on the production of CO_2 emissions in the case of shared vehicles.

RQ2: Which parameters of meal delivery can be changed to make it faster and with lower generation of CO_2 emissions?

In general, the delays in courier services seem to occur primarily in the last mile (Cardenas and Joris 2019). A similar conclusion was made in the case of the company under review, where the delays were caused e.g. by searching for a customer´s delivery address, or parking space, contacting customers, or on the way from the vehicle to the customer´s home. Delays are also caused by traffic, which, however, cannot be influenced by the company. The only solution could be using scooters but in such a case, delivery is not possible under certain weather conditions. The easiest solution would be to hire more couriers who could make deliveries faster and thus reduce the total delivery times. Nevertheless, this solution could be uneconomical for the company, as in periods when the volume of orders is smaller, the company would not have enough work for another employee.

Another solution that would have a positive effect on shortening delivery times is to make customers pick up their orders and ideally wait for the courier to arrive. This would also reduce the production of CO_2 emissions because couriers would not leave their cars running while waiting for the customers and drive around the area to find

a suitable parking space. However, the company would probably never be able to persuade the majority of its customers to do so; therefore, this solution is not suitable.
RQ3: Is it possible to propose a model of meal delivery within the Point To Point mode, which would lead to the reduction of delivery times and production of CO_2 emissions compared to the current standard in the CR?
The proposed solution is based on the delivery within the Point To Point mode where meals are delivered to the distribution centers adapted for the temporary preservation of meals while maintaining their temperature and complying with all hygienic requirements. As in the study by Cardenas and Beckers (2019), there will be a reduction in vehicle kilometers traveled and the production of CO_2 emissions.
This will reduce the time spent on the last mile as well as the costs thanks to their partial transfer to the customer. Couriers will be able to leave out some activities or steps and if two or more orders are delivered to the distribution center, there will also be some savings on fuel.
Distribution centers are located in the most suitable places in terms of the number of orders delivered to a given zone. The most suitable locations turn out to be the places with a higher concentration of inhabitants, while places with houses spread over a large area are unsuitable since the residents would have to walk long distances.

Conclusion

The goal of the paper was to design a system of meal delivery in the Point To Point mode, which would lead to shortening the delivery times and the reduction of CO_2 emissions compared to the current standard in the CR. The goal of the paper was fully achieved.
The use of the distribution centers in the Point To Point system enables companies to improve their competitiveness compared to other companies operating in the same field. This innovation has already been used for the delivery of different types of shipments and customers are already used to this method of picking up their shipments. Therefore, it will be easier to adopt this system when delivering meals. On the other hand, the major advantage of the PTP system is the possibility of picking up the shipment anytime regardless of when the courier delivers it; in the case of meal delivery, however, it is necessary to pick up meals within a specific time, otherwise, hygiene regulations are violated.
The implementation of the proposed solution is advantageous for companies, as it reduces the delivery times, which is given both by faster delivery and faster process of receiving orders. Orders are made using an application or online on the websites of a given company where the customer can choose a meal, place and time of delivery, and pay for the meal. This eliminates several activities concerning taking orders, as they are sent directly to the tablet situated in the kitchen of a given restaurant.
The main advantage of meal delivery using the PTP system is the absence of direct contact with the customer. Thanks to couriers, several time-consuming activities, such as the journey to the customer or payment for the order, are eliminated. If the

pizzeria is too busy, the delivery times may be reduced; in contrast, they can be longer if the number of orders is lower. This is mainly because if couriers deliver more than one order to the same distribution center, the average delivery time is about 9 min 36 sec shorter. If couriers have to deliver orders to different distribution centers, the delivery process will not be reduced much.
The main limitation of this solution is the use of PTP distribution centers. Customers will have to get used to using these centers and prefer shorter delivery times over convenience. If companies use distribution centers and conventional delivery, it may happen that conventional delivery to the zone where the distribution center is located will be only 5 min longer than delivery made using the PTP system. Therefore, it is necessary to consider the alternative of abolishing conventional delivery to given zones to achieve the maximum utilization of the PTP delivery system by customers. However, this will probably lead to the loss of some customers.

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ZARZĄDZANIE REDUKCJĄ EMISJI CO2 W DOSTAWACH POSIŁKÓW PRZY UŻYCIU SYSTEMU POINT TO POINT

Streszczenie: Celem artykułu było zaproponowanie systemu dostaw gotowych posiłków w trybie Point To Point (PTP), który doprowadziłby do skrócenia czasu dostawy i zmniejszenia emisji CO2 w porównaniu ze standardem obowiązującym w Czechach. Niniejsze badanie proponuje nowe podejście, które może zrewolucjonizować regionalny sektor dostaw posiłków poprzez strategiczną integrację centrów dystrybucji i uwzględnienie czynników ekonomicznych. Odpowiednią lokalizację dla centrów dystrybucyjnych stworzonych w celu dostarczania posiłków do konsumentów końcowych można określić za pomocą wielu metod. Jako najbardziej odpowiednią wybrano metodę lokalizacji środka ciężkości w zależności od odległości oraz liczby zamówień i dostaw do danych miejscowości. Obliczenie zwrotu z kapitału własnego zostało wykorzystane do określenia zwrotu z inwestycji niezbędnego do wdrożenia proponowanego rozwiązania. Badania wykazały, że wdrożenie proponowanego rozwiązania zmniejszyłoby produkcję CO2 o ponad 12%, wraz z redukcją kosztów paliwa i eksploatacji pojazdów wykorzystywanych do usług dostawczych. Jednocześnie możliwe byłoby skrócenie czasu dostawy o 40%. Ustalenia pokazują, że średni czas dostawy, który waha się od 66 do 116 minut, ma znaczący wpływ na konkurencyjność, powodując odpływ klientów. Badanie wykryło również zróżnicowane ilości emisji CO2, przy czym główny pojazd emitował 37,4 kg CO2 każdego dnia. Sugerowana strategia kładzie nacisk na dostarczanie posiłków do strategicznie zlokalizowanych centrów dystrybucji, przy jednoczesnym zachowaniu zgodności z przepisami dotyczącymi temperatury i higieny. Strategia ta może potencjalnie zminimalizować liczbę przejechanych kilometrów i emisję CO2, poprawiając tym samym wydajność operacyjną. Wreszcie, badania pokazują potencjał innowacyjnej metody rewolucjonizowania usług dostarczania żywności, z korzyścią zarówno dla firm, jak i środowiska.

Słowa kluczowe: Point to Point, centra dystrybucyjne, magazynowanie, logistyka, usługi dostawcze, dostawa posiłków